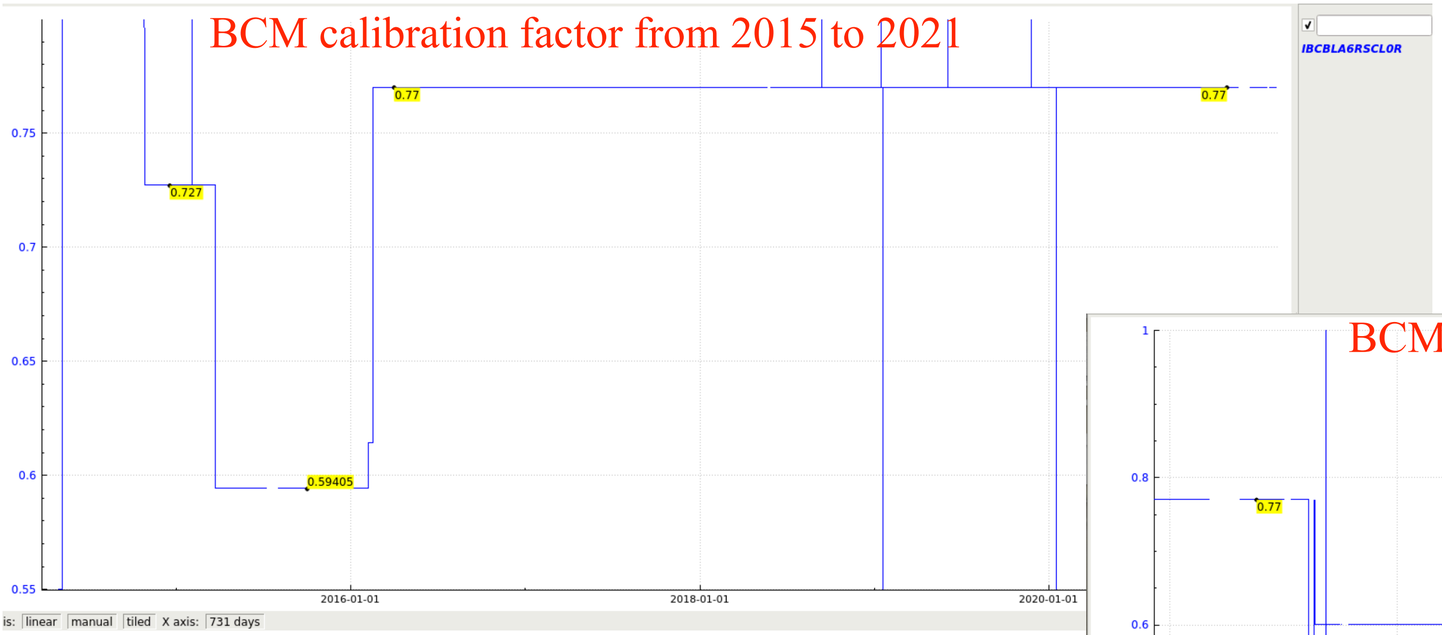
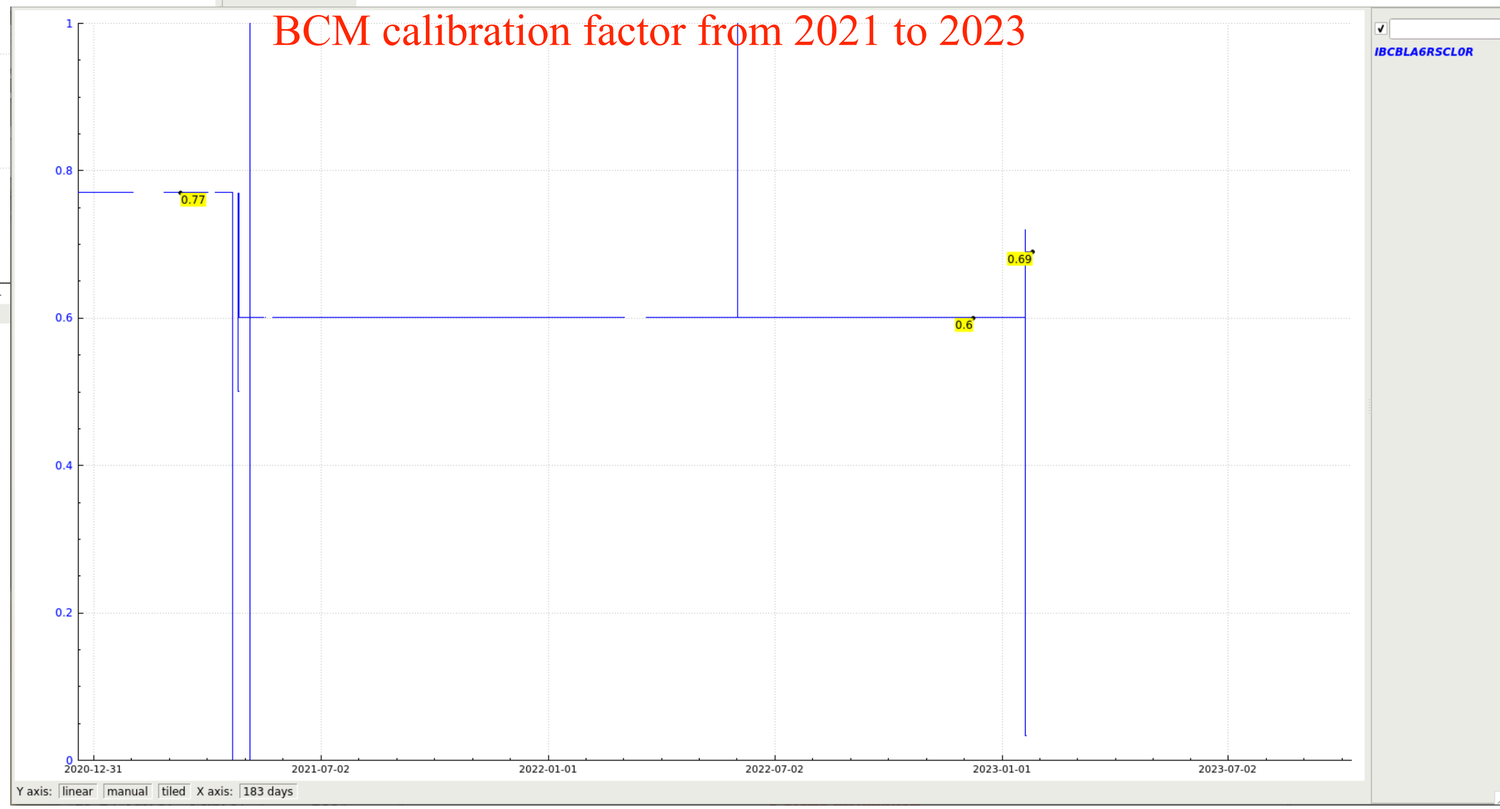
TAGH yield and BCM calibration history

A. Deur, 02/02/2023

In January 2023, it was discovered that rates in the PS and GlueX detectors differed by 30% compared to the run period of 2020. After checking the rates with different aluminum radiator thickness, the issue was traced back to the calibration of our BCMs. Discussions with Ops revealed that the BCM calibration (called BLA calibration) is not done systematically before each run period and the last calibration was done in 2021. The Figures below show the values of the BCM calibration factor from 2015 to 2023.





As far as Hall D production is concerned, the factor was 0.77 for most of the time. It was set to 0.6 in 2021 and then to 0.69 on 01/19/2023 after we (Hall D) asked for a BCM calibration.

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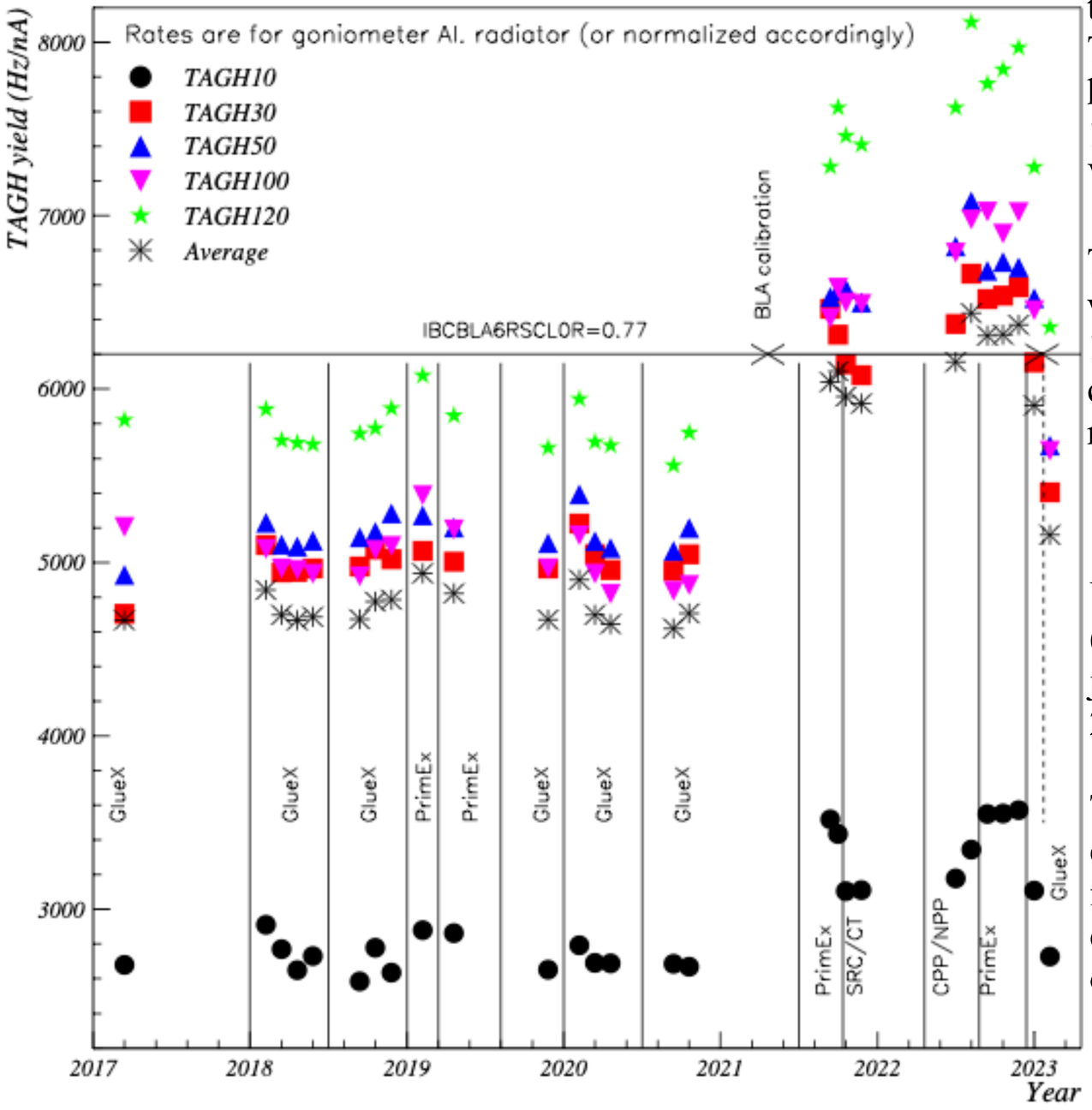
Assuming that the TAGH performance has been stable over the history of Hall D, one can track the change in BCM calibration by looking at the TAGH yield (i.e., rate normalized by electron beam current) history. If the TAGH is stable, any change in yield is an artifact. The figure shows the history of the yield (Hz/nA) for 5 different TAGH counters (10, 30, 50, 100 and 120) from the first GlueX production period in 2017 to 2023. We also show the yield average over the 5 counters (✳ symbol).



The yields are from the goniometer aluminum radiator (40μm) or, when not available (PrimEx runs or first GlueX run in 2017), from the 10μm radiator of the amorphous radiator ladder, with the corresponding yields normalized by the thickness ratio of the two radiators.

We see that the TAGH yield was stable up to 2021. It jumped (artificially) in 2021 after the BLA calibration factor changed and then jumped back to approximately its post-2021 level after the Jan. 17th 2023 BLA calibration (dashed line).

There is a small but clear step between the SRC/CT and CPP/NPP experiments that is not linked to a change in BCM calibration factor. It is marked for low energy counters (#120, #100) but less so for higher energy counters (#10, #30). This suggests the beam quality as the cause of this small jump.

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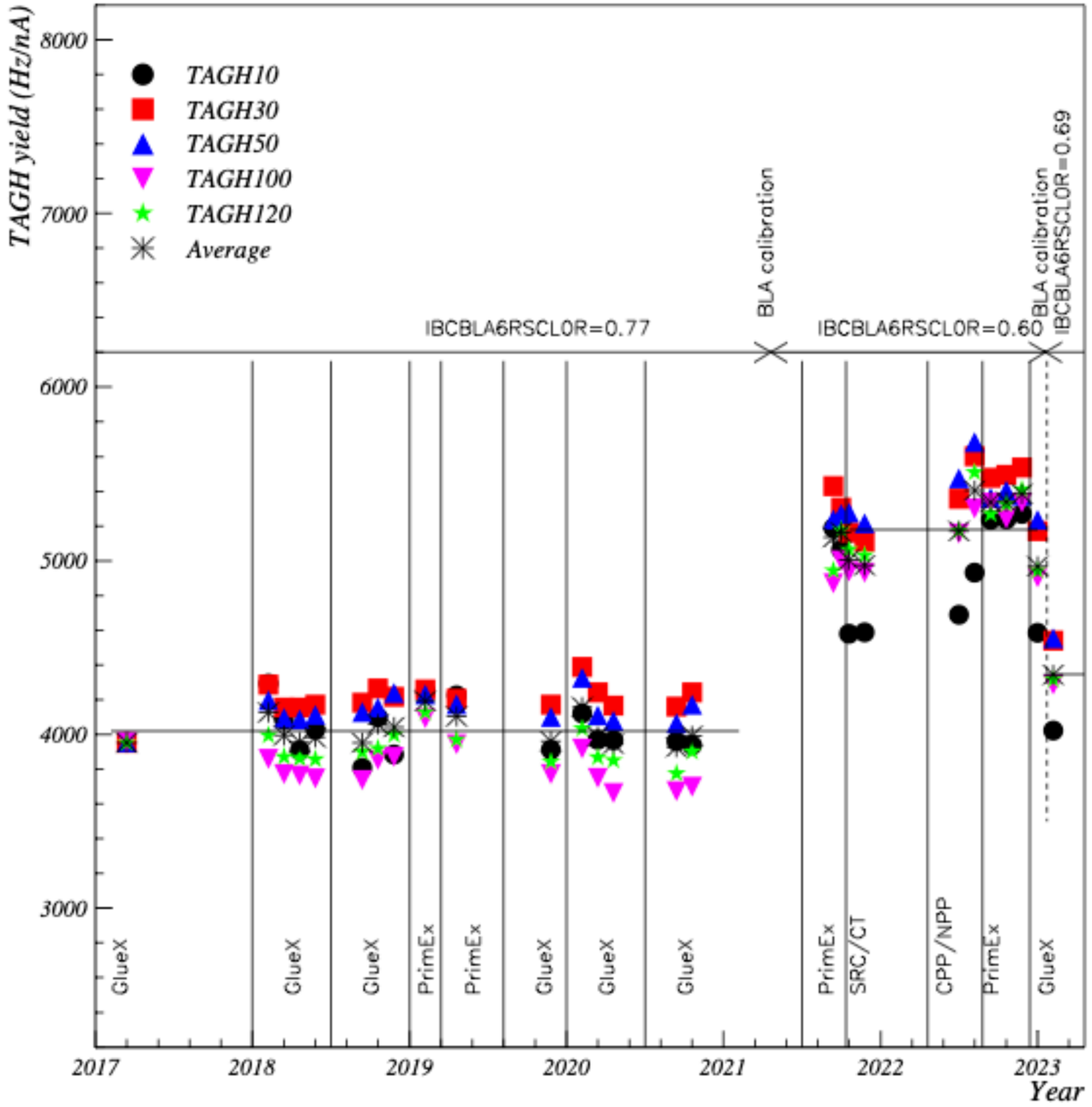

This is the same as the previous figure, but with the TAGH rates matched to each other in 2017. It makes the two steps when the BCM calibration more obvious.

If we fit the average TAGH rate, we find that it was:

- 4020 from 2017 to 2021;
- 5180 from 2021 to 2023 (a factor 1.288 compared to 2017-2021);
- 4350 in 2023 (a factor 1.082 compared to 2017-2021).

The 1.288 factor matches nearly exactly the change 0.77/0.60=1.283 in calibration factor.
The 1.082 factor matches approximately the change 0.77/0.69=1.116 in calibration factor.

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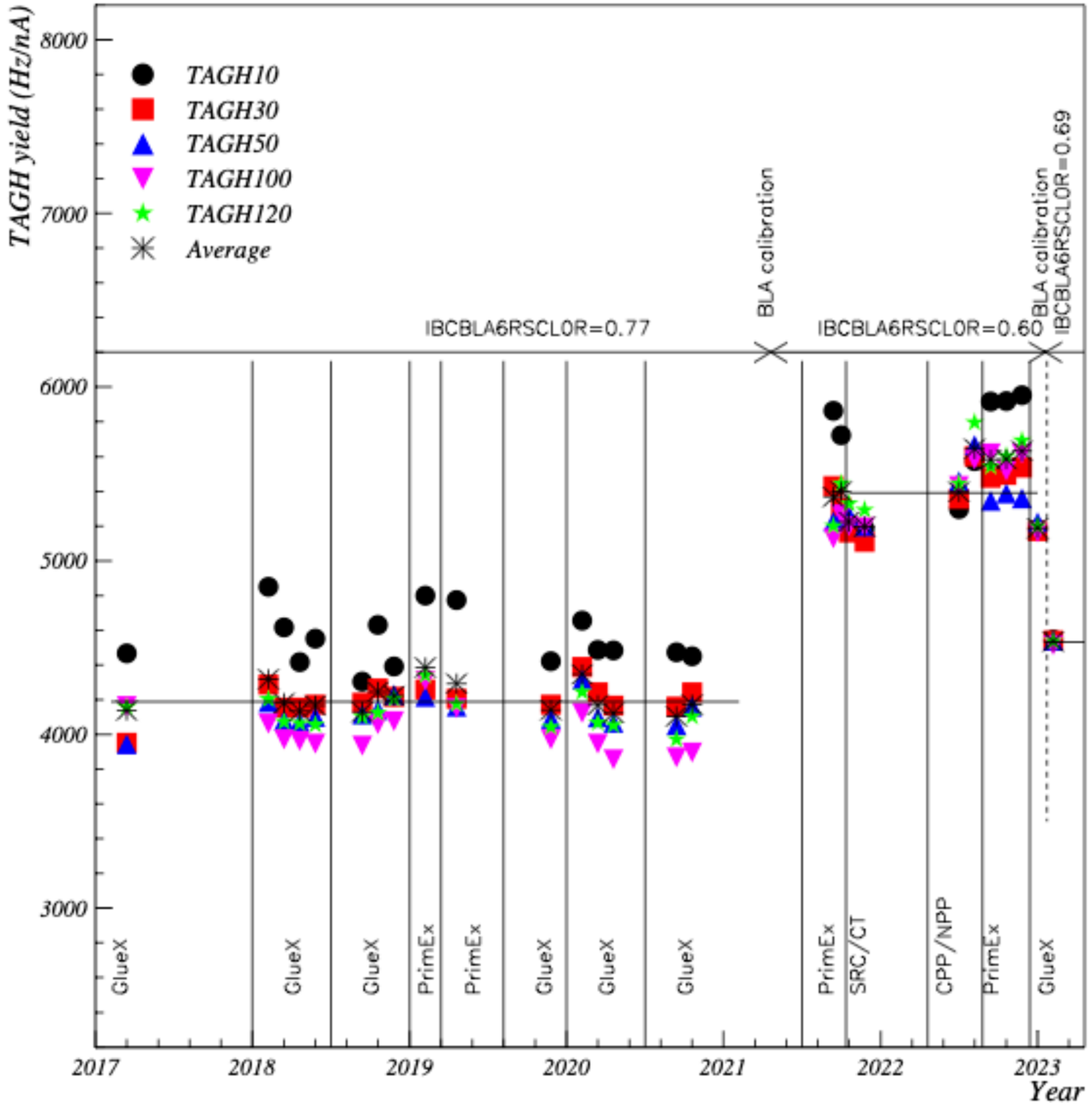


This is the same as the previous figure, but with the TAGH rates matched to each other in 2023.

If we fit the average TAGH rate, we find that it was:

- 4190 from 2017 to 2021,
- 5390 from 2021 to 2023 (a factor 1.286 compared to 2017-2021),
- 4530 in 2023 (a factor 1.081 compared to 2017-2021),

in agreement with the previous figure.

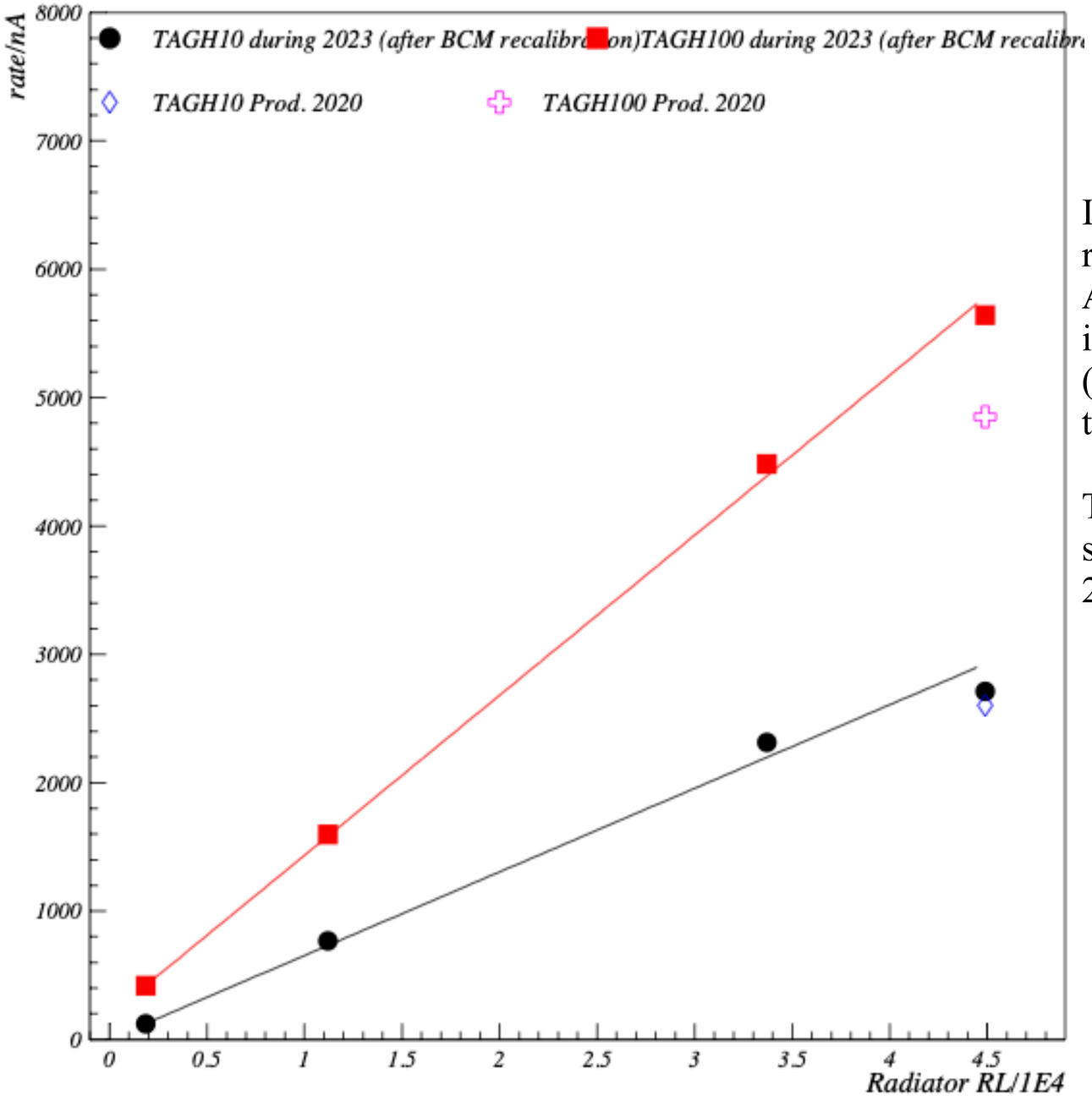
This and the previous ratios strongly indicate that:

- The TAGH yields are stable over the 2017-2023 period.
- The *actual* BCM calibration factor is essentially constant (rather than changing from 0.77 to 0.60 to 0.69.)

This only tells us about the evolution (or lack thereof) of the calibration factor, not what its value should be to provide an accurate electron beam current.

TAGH yield and BCM calibration history

A. Deur, 02/02/2023



Initially, it was thought the ~30% change in rate could be due to a radiator problem. Therefore, we checked the linearity of the yield with Al. radiator thickness, see figure. It appears linear as expected, making it very unlikely that there is a problem with the radiator, since all (goniometer+amorphous radiator ladder) would have to be affected in the same way.

The yields are after the 2023 BCM calibration, except for the open symbols which are for 2020. The mismatch between the 2023 and 2020 data is the effect of the recalibration.

Conclusion

The actual calibration factor of the BCM appears stable and changing it from 0.77 and 0.60 and then 0.69 was not warranted, as far the reproducibility from run period to run period is concerned. For ex. the beam current of 350 nA according to the BCM before 2021 actually became 450nA after 2021 for the 350nA readout of the BCM.

We do not know the accuracy of the BCM calibration factor, only its reproducibility. This means we do not know the absolute beam current in Hall D. This has no consequence on the physics data analysis: the BCM current is used only for online diagnostic, to normalize rates and compare them to previous run periods to check that nothing is amiss with the data taking. For the physics analysis however, it is the photon beam flux that is important and it is measured precisely with the pair spectrometer normalized by TAC runs. Yet, we do need a BCM accuracy and reproducibility at reasonable level, say below 10%.

The TAGH yields are stable and a good way to approximately monitor the current as long as it is done with an aluminum radiator.